

What is claimed is:

1. A method of manufacturing a semiconductor device, comprising:

a first step of forming a semiconductor film having an amorphous structure on an insulating surface;

a second step of adding a metallic element to the semiconductor film having an amorphous structure;

a third step of heat-treating the semiconductor film having an amorphous structure to form a semiconductor film having a crystalline structure, and then removing an oxide film from the crystalline semiconductor film surface;

a fourth step of introducing oxygen into the semiconductor film having a crystalline structure to make an oxygen concentration within the film from $5 \times 10^{18}/\text{cm}^3$ to $1 \times 10^{21}/\text{cm}^3$;

a fifth step of removing an oxide film on the surface of the semiconductor film having a crystalline structure; and

a sixth step of irradiating laser light under an inert gas atmosphere or in a vacuum to level the surface of the semiconductor film having a crystalline structure.

2. A method of manufacturing a semiconductor device, comprising:

a first step of forming a semiconductor film having an amorphous structure on an insulating surface;

a second step of adding a metallic element to the semiconductor film having an amorphous structure;

a third step of heat-treating the semiconductor film having an amorphous structure to form a semiconductor film having a crystalline structure;

a fourth step of introducing oxygen into the semiconductor film having a crystalline structure to make the oxygen concentration within the film from $5 \times 10^{18}/\text{cm}^3$ to $1 \times 10^{21}/\text{cm}^3$;

a fifth step of removing an oxide film on the surface of the semiconductor film having a crystalline structure; and

a sixth step of irradiating laser light under an inert gas atmosphere or in a vacuum to level the surface of the semiconductor film having a crystalline structure.

3. A method of manufacturing a semiconductor device, comprising:
a first step of forming a semiconductor film having an amorphous structure on an insulating surface;
a second step of adding a metallic element to the semiconductor film having an amorphous structure;
a third step of heat-treating the semiconductor film having an amorphous structure to form a semiconductor film having a crystalline structure, and then removing an oxide film from the crystalline semiconductor film surface;
a fourth step of introducing oxygen into the semiconductor film having a crystalline structure to make the oxygen concentration within the film from $5 \times 10^{18}/\text{cm}^3$ to $1 \times 10^{21}/\text{cm}^3$;
a fifth step of removing an oxide film on the surface of the semiconductor film having a crystalline structure;
a sixth step of irradiating laser light under an inert gas atmosphere or in a vacuum to level the surface of the semiconductor film having a crystalline structure; and
a seventh step of gettering the metallic element to remove the metallic element from, or reduce the concentration of the metallic element within, the semiconductor film having a crystalline structure.

4. A method of manufacturing a semiconductor device according to claim 1, wherein a concentration of oxygen within the semiconductor film having an amorphous structure and formed by the first step is less than $5 \times 10^{18}/\text{cm}^3$.

5. A method of manufacturing a semiconductor device according to claim 2, wherein a concentration of oxygen within the semiconductor film having an amorphous structure and formed by the first step is less than $5 \times 10^{18}/\text{cm}^3$.

6. A method of manufacturing a semiconductor device according to claim 3, wherein a concentration of oxygen within the semiconductor film having an amorphous structure and formed by the first step is less than $5 \times 10^{18}/\text{cm}^3$.

7. A method of manufacturing a semiconductor device according to claim 1, wherein the fourth step is a step of irradiating laser light under an inert gas atmosphere, or in a vacuum, after oxidizing the semiconductor surface having a crystallization structure by using ozone water, the laser light having an energy density which is lower than the energy density of the laser light used in the sixth step by 30 to 60 mJ/cm².

8. A method of manufacturing a semiconductor device according to claim 2, wherein the fourth step is a step of irradiating laser light under an inert gas atmosphere, or in a vacuum, after oxidizing the semiconductor surface having a crystallization structure by using ozone water, the laser light having an energy density which is lower than the energy density of the laser light used in the sixth step by 30 to 60 mJ/cm².

9. A method of manufacturing a semiconductor device according to claim 3, wherein the fourth step is a step of irradiating laser light under an inert gas atmosphere, or in a vacuum, after oxidizing the semiconductor surface having a crystallization structure by using ozone water, the laser light having an energy density which is lower than the energy density of the laser light used in the sixth step by 30 to 60 mJ/cm².

10. A method of manufacturing a semiconductor device according to claim 1, wherein the fourth step is a step of irradiating laser light under an atmosphere containing oxygen or water molecules, the laser light having an energy density which is lower than the energy density of the laser light used in the sixth step by 30 to 60 mJ/cm².

11. A method of manufacturing a semiconductor device according to claim 2, wherein the fourth step is a step of irradiating laser light under an atmosphere containing oxygen or water molecules, the laser light having an energy density which

is lower than the energy density of the laser light used in the sixth step by 30 to 60 mJ/cm².

12. A method of manufacturing a semiconductor device according to claim 3, wherein the fourth step is a step of irradiating laser light under an atmosphere containing oxygen or water molecules, the laser light having an energy density which is lower than the energy density of the laser light used in the sixth step by 30 to 60 mJ/cm².

13. A method of manufacturing a semiconductor device according to claim 1, wherein the fourth step is a step of irradiating laser light under an inert gas atmosphere, or in a vacuum, after adding oxygen by ion doping or ion implantation so that the oxygen concentration within the semiconductor film having a crystallization structure is from $5 \times 10^{18}/\text{cm}^3$ to $1 \times 10^{21}/\text{cm}^3$, the laser light having an energy density which is lower than the energy density of the laser light used in the sixth step by 30 to 60 mJ/cm².

14. A method of manufacturing a semiconductor device according to claim 2, wherein the fourth step is a step of irradiating laser light under an inert gas atmosphere, or in a vacuum, after adding oxygen by ion doping or ion implantation so that the oxygen concentration within the semiconductor film having a crystallization structure is from $5 \times 10^{18}/\text{cm}^3$ to $1 \times 10^{21}/\text{cm}^3$, the laser light having an energy density which is lower than the energy density of the laser light used in the sixth step by 30 to 60 mJ/cm².

15. A method of manufacturing a semiconductor device according to claim 3, wherein the fourth step is a step of irradiating laser light under an inert gas atmosphere, or in a vacuum, after adding oxygen by ion doping or ion implantation so that the oxygen concentration within the semiconductor film having a crystallization structure is from $5 \times 10^{18}/\text{cm}^3$ to $1 \times 10^{21}/\text{cm}^3$, the laser light having an energy density which is lower than the energy density of the laser light used in the sixth step by 30 to 60 mJ/cm².

16. A method of manufacturing a semiconductor device according to claim 1, wherein the metallic element in the above structure is a metallic element for promoting crystallization of silicon, and is one element, or a plurality of elements, selected from the group consisting of Fe, Ni, Co, Ru, Rh, Pd, Os, Ir, Pt, Cu, and Au.

17. A method of manufacturing a semiconductor device according to claim 2, wherein the metallic element in the above structure is a metallic element for promoting crystallization of silicon, and is one element, or a plurality of elements, selected from the group consisting of Fe, Ni, Co, Ru, Rh, Pd, Os, Ir, Pt, Cu, and Au.

18. A method of manufacturing a semiconductor device according to claim 3, wherein the metallic element in the above structure is a metallic element for promoting crystallization of silicon, and is one element, or a plurality of elements, selected from the group consisting of Fe, Ni, Co, Ru, Rh, Pd, Os, Ir, Pt, Cu, and Au.

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